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(54) Title: METHOD AND SYSTEM FOR MANUFACTURING OPTICAL ELEMENTS AND OPTICAL ELEMENT

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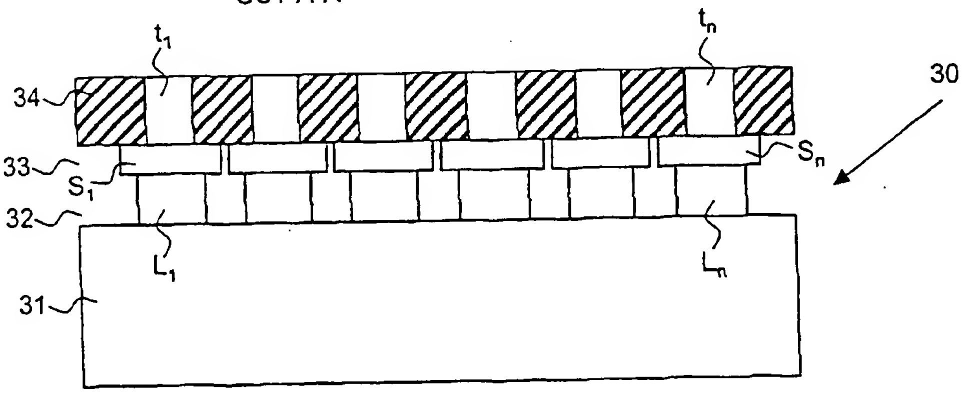

(57) Abstract: The invention concerns a method for manufacturing optical elements, which method comprises the steps of supplying a printing cylinder with printing elements for forming optical structures, applying optical material on the printing cylinder and creating the optical structures on the substrate material web or substrate material sheets. The invention also concerns a method for manufacturing a printing cylinder for the use in the printing unit for manufacturing optical elements, which printing cylinder comprises a printing surface. The method comprises the steps of applying a gray-scale mask on the fabrication of the printing surface, exposing photosensitive materials through the gray-scale mask with electromagnetic radiation, removing the gray-scale mask, and etching the printing surface to a printing plate or to the cylinder. The invention further concerns a printing system for carrying out the method for manufacturing optical elements. The printing system comprises a printing cylinder provided with printing elements for printing optical elements. The invention also concerns an optical element (30) comprising a substrate layer and a layer of optical structures, in which optical element the substrate layer (31) is paper. The invention still further concerns a printed optical element in which the optical structure is printed on substrate material with a printing system comprising a printing cylinder.

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Method and system for manufacturing optical elements and optical element

The present invention relates to a method for manufacturing optical elements. The present invention also relates to a method for manufacturing a printing cylinder for the use in the printing unit for manufacturing optical elements. The invention further concerns a printing system, an optical element and a printed optical element.

Micro-optical elements and optoelectrical elements are optical components, which contain structures with typical dimensions of the order of a few micrometers to 1 mm in thickness and a few centimeters in length or diameter. Later in this text we refer the micro-optical elements and optoelectrical elements as optical elements.

Optical elements may be integrated with other electronic components into integrated circuits or printed circuit boards. With optical elements and integrated optical elements it is possible to achieve high-speed optical signal propagation or high sensitivity for the use of e.g. telecommunication, data communication, computer industries, and bioanalytics. Examples of a micro-optical components are waveguides, gratings, splitters, combiners, and free space lenses as well as active components, such as light sources and detectors. Optoelectronics deals with the integration of electronic processes with light and optical processes. Devices in which such integration suitably takes place, usually accompanied by an energy conversion process (e.g. from electrical to optical, and vice versa) are called optoelectronic devices. Such devices conveniently comprise semiconductors, both inorganic and organic or their combinations, or their combinations to other than semiconductor optical materials such as glasses and polymers etc.

It is known from prior art to use optical and integrated optical elements in telecommunication components and systems. For example, an optical power splitter is

one of key components in subscriber networks of optical communications for dividing an optical signal into two or more branches. These components can be made by applying either optical fibres or waveguides (Optical Integrated Circuit, Nishihara, Haruna and Suhara, McGraw-Hill 1989).

It is known from prior art to use optical elements in bio-sensors where a biological sample, e.g. blood sample, to be tested is put on a bio-sensor and is then analyzed from the change of wavelength in the light passing through the sensor. These kind of optical components are typically quite expensive which is a draw-back of their wide use.

It is known to use micro-optical components in optical systems to collect, distribute or modify optical radiation. Refractive, reflective and diffractive components, such as lenses, prisms and mirrors are well-known (Micro-optics: Elements, system and applications, Hans Peter Herzig, Taylor & Francis 1997). In addition, integrated optical components are well understood (Optical Integrated Circuit, Nishihara, Haruna and Suhara, McGraw-Hill 1989). Following trend of miniaturisation, novel technologies have been developed to shrink the size and increase functionality of these elements. The manufacturing technologies of micro-optical components in most cases exploit the flexibility and precision of VLSI (Very Large Scale Integration) circuit processing methods, which may include photolithographic methods, RIE etching (Reactive Ion Etching), Excimer laser ablation, molding, casting, and embossing. These manufacturing methods are slow batch processes. E.g. direct photolithographic production of micro-optical elements comprises steps of deposition and lithographic patterning of several polymer layers.

It is also known in the prior art to manufacture polymeric optical circuits using a reel-to-reel production technique which embosses the desired micro-optical pattern on rolls of PET film material (Polymeric Optoelectronic Interconnects, Louay Eldada, Optoelectronic Interconnects VII: Photonics Packaging and Integration II,

Proceedings of SPIE Vol. 3952 (2000)). In this method remarkable uniformity is obtainable over a large surface, but the drawback of the method is an additional degree of roughness to the waveguides which adds to some optical scattering loss. By this method a roll of plastic fully populated with dense interconnect circuits can be embossed at a rate of 70 feet/min (21 m/min).

The main problem with the production of the prior art optical elements is that they are expensive to manufacture and that current techniques are difficult to scale up for mass production.

The object of the present invention is to provide a novel production method for optical elements which is fast and inexpensive compared with prior art methods.

Another object of the present invention is to provide a method to integrate structured optical materials on existing optical and/or non-optical materials, structures and devices.

A further object of the present invention is to provide a method for producing a printing means for optical structures and devices.

A still further object of the present invention is to provide a novel optical element.

In view of achieving of the objectives stated above the method for manufacturing optical elements is mainly characterised in that the method comprises the steps of supplying a printing cylinder with printing elements for forming optical structures, applying optical material on the printing cylinder and creating the optical structures on the substrate material web or substrate material sheets.

The method for manufacturing a printing cylinder for the use in the printing unit for manufacturing optical elements is characterised in that the method comprises the steps of applying a gray-scale mask on the fabrication of the printing surface,

exposing photosensitive materials through the gray-scale mask with electromagnetic radiation, removing the gray-scale mask, and etching the printing surface to a printing plate or to the cylinder.

A printing system for carrying out the method for manufacturing optical elements is characterised in that the printing system comprises a printing cylinder provided with printing elements for printing optical elements.

An optical element according to the invention is characterised in that the substrate layer of the optical element is paper.

A printed optical element according to the invention is characterised in that the optical structure is printed on substrate material with a printing system comprising a printing cylinder.

According to the invention optical elements are produced in a printing system in which the optical element is transferred from the printing cylinder to a suitable substrate material. In an extreme case the whole substrate material can be covered with optical material. The substrate material is paper or plastic or other passive or active optical/electrical material, such as a semiconductor material. The substrate material is in a form of a web or separate sheets of suitable size. Optical material is a material system that can be handled and delivered in the liquid format to its final location, e.g. substrate, in which it forms to a stable or metastable phase, i.e. a solid or metasolid form. After taking the stable or metastable phase the material presents optical properties, which can be for example transparency or selective transparency, reflectivity, diffraction, light emission, laser activity, photo-voltaic generation, polarisation selectivity, modulation or phase modulation, and photochemical reactivity when interacting with electromagnetic radiation or electrons. The optical material can be e.g. an organic polymer that is dissolved in an appropriate solvent. The material can also be a suspension of solid particles in a liquid carrier. In both cases the material forms stable or metastable form when the sol-

vent or the carrier is removed. However, the invention is not restricted to these materials.

The manufacturing of the optical elements according to the invention comprises the primary printing step in which the optical element is formed on the substrate surface using the primary printing method. The primary printing system is preferably a gravure printing system, a gravure offset printing system, a flexographic printing system, an offset lithographic system, electrophotographic printing system, or a combination of these.

Gravure printing includes direct gravure printing, in which the printable pattern is transferred from the printing cylinder to the printing surface, gravure offset printing in which the printable pattern is transferred from the printing cylinder to a second cylinder and from it to the printing surface, and intaglio printing. In intaglio printing process viscous inks are used which allow the printing patterns of larger uniform areas.

After the primary printing phase the printed optical element is optionally treated with an additional printing method(s). In the additional printing phase devices for digital printing, hot stamping, silk screen printing and/or photolithographic printing may be applied.

The present invention makes it possible to produce high quality optical elements at a cost which is a remarkably lower than when using conventional methods. This is preferably achieved by manufacturing a printing cylinder provided with surface structures to form optical elements on a substrate material. The printed optical component is formed by using a liquid form optical material that is suitable for printing systems, and is, if needed, cured with suitable method. The printed optical elements can further be laminated, covered or printed with additional optical layers. The curing method can be such as thermal curing or UV curing.

The main advantage of the present invention is the possibility to mass produce optical elements with low cost. This allows the use of optical elements in many new applications, like in low-end optical communication, fiber-to-the-home (FTTH) applications, disposable biosensors, identifiers of packages, etc.

Because of the relatively low cost of the end product when producing optical elements according to the invention the present invention can be utilized especially in applications in which disposable components are used, such as biosensors testing e.g. biomedical samples such as blood samples.

The invention is preferably implemented in a gravure printing process. In gravure printing the gravure cells forming the printable pattern are engraved or etched in a metal layer on the printing cylinder. According to the invention a specific gravure printing cylinder is manufactured for the printing process.

Advantages of using the gravure printing method are deep enough structures achievable in gravure printing, high quality of the transfer of the printing pattern, high throughput, and low price compared to the conventional methods of producing optical elements. The gravure printing method can also be easily integrated to other process parts such as lamination, coating or embossing.

In the following the invention will be described in detail with reference of the figures in the accompanying drawing:

Figure 1A shows an example of an optical element.

Figure 1B shows a cross-section of an optical element.

Figure 2 shows an example of a printing system according to the invention.

Figure 3 shows a cross-section of a printing element for the production of optical elements.

Figure 4 shows an example of the printing system comprising an offset printing unit.

Figure 5A shows an example of the printing system according to the invention comprising a combination of different printing units placed one after another.

Figure 5B shows an example of the printing system according to the invention comprising a combination of different printing units placed in parallel.

Fig. 1A shows an example of an optical element. The optical element 30 in this example is a waveguide acting as an optical power splitter and it is used as a biosensor. In the optical element 30 light beam L_{in} enters to the input of the optical element 30 and is then split in several light beams $L_1 \ldots L_n$. Each light component passes a sensitive area $S_1 \ldots S_n$ each of which consists of e.g. a suitable bioactive material. The sample to be tested is put in contact with the sensitive areas $S_1 \ldots S_n$. The bioactive material in the sensitive area $S_1 \ldots S_n$ reacting with the test sample changes the propagation in the light beams $L_1 \ldots L_n$ and provide this way information of the sample properties. The changes in the light propagation can be due to the changes in refractive index or absorption of the material. The propagating light may also generate an excited emission, for example, due to luminescence or phosphorescence.

Fig. 1B shows the cross cutting A-A of the optical element 30 of Fig. 1A. The optical element 30 comprises a substrate layer 31, a layer 32 for optical components, a layer 33 for sensitive areas $S_1 \ldots S_n$ and a coating layer 34. The coating layer 34 comprises lead-throughs $t_1 \ldots t_n$ for passing the sample material to the sensitive areas $S_1 \ldots S_n$ thereby to be in contact with them. The substrate material layer 31 is e.g. paper, plastic or other passive or active optical/electrical material. The optical component layer 32 may comprise several sub-layers in which optical

components lay on each other. The sensitive material layer 33 comprises sensitive material for analytical use. The sensitive material layer 33 is printed or other wise applied on the optical component layer 32 during the manufacturing phase of the optical element 30. The coating layer 34 is e.g. a laminate layer. Depth of the layers are of the order of tens of nanometers to tens of micrometers of the substrate material layer 31, of the optical component layer 32, of the sensitive material layer 33 and of the coating layer 34. The invention is, however, not limited to said layer depths.

Fig. 2 shows an example of a printing system comprising a printing cylinder 20 according to the invention. The printing system 100 is used for printing the optical element to the web in the primary step of manufacturing optical elements. The web W of substrate material enters the printing system 100 which comprises an impression cylinder 10, a printing cylinder 20 and a container 40. The surface of the printing cylinder 20 is provided with printing elements 50. The ink container 40 contains optical material which is passed via the printing elements 50 on the web W to form optical elements 30. Instead of printing on the web it is also possible to print on sheet material.

The printing system 100 may also contain a curing unit 60 which cures the web W by e.g. light and/or laser activation and/or thermal activation, or other known curing method. The curing unit 60 may be placed on either side of the web or on both sides.

The printing system 100 optionally comprises a doctor blade in connection of the printing cylinder 20 for doctoring the excess of the ink from the surface the printing cylinder 20.

The printing cylinder in the primary step of manufacturing the optical elements according to the invention may be a gravure cylinder or a cylinder comprising flexographic plates or electrophotographic cylinder or offset device with printing

areas for forming optical structures. In flexographic printing method the printing areas are above the mean depth of the profile and the nonprinting areas are below. In the offset lithographic printing method the printing cylinder is chemically modulated to form a print pattern. In electrophotographic printing method, the print pattern is generated as a charge pattern by the interaction of light from a printing head with electrical charges deposited on a printing cylinder surface. In digital electrophotography, the exposure results from modulating a light source such as a laser by digital page data. (Papermaking Science and Technology, part 13: Printing, TAPPI Press, 1998)

In additional step the printed optical element is further provided with additional layers to form the desired optical component. Suitable methods for additional treatment of the optical elements are hot stamping, photolithographic printing method and silk screen printing.

In hot stamping printing method, ink coated on a film transfers by heat and pressure to a web. The raised parts of the profile contact the film, and the resulting heat flow causes liquification of the ink. In silk screen printing method the printing plate is replaced by a stencil having different porosity in the printing and non-printing areas. Ink is pressed through the stencil to the paper or other substrate positioned below the stencil. (Papermaking Science and Technology, part 13: Printing, TAPPI Press, 1998)

Photolithography is a method to induce, by light or more generally any kind of electro-magnetic radiation, surface relief or index modulated structures dimensioning typically from nanometers to several millimetres. The photolithography requires photosensitive material(s) that is exposed by light to induce chemical reactions in the material. Changes can effect to the material so that its solubility to a developer alters or its density either increases or decreases. The exposure is executed through a photomask, which then localises the chemical reactions to a lim-

ited regions. After the exposure the photosensitive material can be either developed in the developer or otherwise stabilised, e.g. thermally.

Photolithography includes a holographic printing method, which also requires the photosensitive material, and it can be used to form surface relief or index modulated structures, as well. In the holographic method the interference of two mutually coherent beams are used to expose the photosensitive material. This method typically produces a sinusoidal surface or index-modulation pattern due to light-induced chemical reactions.

According to the invention the additional step for manufacturing optical elements may also include using a stamping unit in which an area consisting of an optical layer is printed on the web and then an optical pattern is stamped on this area. Alternatively, the optical pattern may be exposed on this area using lithographic methods.

Figure 3 shows a cross-section of an embodiment of a printing element for the production of optical elements. The printing element 50 is a gravure printing element and it is formed on the surface of the printing cylinder 20. The printing element 50 contains cells $50_1 \ldots 50_n$ with variable widths and depths. In the printing process the cells are filled with optical material and this material is transferred on the web W.

In the method according to the invention for producing optical elements a printing cylinder is prepared containing printing elements of the form of optical elements. The optical elements are created on a substrate surface running as a web through the printing system. According to the invention the printing elements in the printing cylinder are preferably of the form of lines or other three-dimensional structures instead of point structures of the prior art printing cylinders.

The prior art gravure cylinders comprise printing areas having cells that transfer ink to the web. The printing areas are generated usually by engraving or etching.

Engraving is made with scanners equipped with diamond heads. Also laser engraving can be applied. A computer may feed information directly to the engraving heads, or it may come from a page film mounted on an input drum. The scanners can read continuous tone page films and convert the signal to instructions for the engraving heads. (Papermaking Science and Technology, part 13: Printing, TAPPI Press, 1998)

After engraving or etching, gravure cylinders may receive a chrome plating to improve surface durability. A chromium plated gravure cylinder can print millions of copies.

In the etching method light sensitive pigment paper controls the etching process. The paper undergoes exposure through a positive, continuous tone page film and a special gravure screen. After exposure, washing the paper with water provides the relief. The paper relief wrapped around a copper cylinder controls diffusion of the acid and the cell depth.

In an etched gravure cylinder, the area of each cell is equal, but the depth varies with the density level in the page film. In engraved cylinders, the cell area and the cell depth vary. Due to the different cell structures, etched and engraved cylinders give different printing results.

Besides engraving and etching, other less common methods of gravure cylinder making are possible. An autotypic gravure cylinder is coated with a radiation sensitive layer like radiation sensitive offset plates. Exposure occurs through page films. Etching occurs similarly to etching of multi metal offset plates. The difference from etched cylinders is that the pictures in autotypic cylinders are normal halftones, and text is not screened.

For the fabrication of optical element by means of different gravure printing methods a modified printing rolls are preferably applied. These rolls are processed

by using a gray-scale mask (see Canyon Materials, Inc., San Diego, CA, USA; T. Hessler et al. Appl. Opt. 37 (1998) 4069; W. Däschner et al. Appl. Opt. 36 (1997) 4259) in the patterning steps of the physical structures into the cylinder. This method has not been applied to the gravure cylinders before. The gray-scale mask provides a possibility for manufacturing of printing cylinders, which is utilised for fabrication of complex and high-resolution optical components such as multi-phase-level diffractive elements. In the processing of the cylinder the gray-scale mask is used for patterning of the photo resist that is coated on a metallic plate. The photo resist is exposed by using UV light (or other electromagnetic radiation) through the gray-scale mask after which the resist is developed resulting surface relief structures comparable to optical densities in the mask. The relief structures are then transferred to the metallic plate by using conventional etching methods such as chemically assisted ion-beam etching (CAIBE) or Reactive Ion Etching (RIE) or wet-etching. The method also provides a possibility to generate large area continuos structures with variable heights.

The method according to the invention may also be carried out with an offset printing system as shown in Fig. 4. In the offset printing system 200 the ink is first applied from the ink container 240 on the printing cylinder 220. Then the print pattern is transferred to the offset cylinder 225 which transfers the pattern on the web W. The impression cylinder 210 supports the web W in the printing nip.

According to the invention the printing system may be a combination of two or more printing systems comprising e.g. gravure and/or flexographic and/or offset lithographic and/or digital printing techniques and/or stamping units. These units may be placed one after another as shown in Fig. 5A which shows a manufacturing system comprising five units 100, 200, 300, 400, 500 which treat the web W by applying different layers needed to form optical elements on the web. The web is aligned in each of the units using prior art aligning methods. Fig. 5B shows an example in which the units are placed in parallel and the printed layers W_1, W_2, W_3, W_4, W_5 are combined in the laminating unit 1100. In the after-treatment unit

1200 the optical elements are separated by cutting the web in sheets of suitable sizes.

In the following the patent claims will be given and various details of the invention may show variation within the scope of the inventive idea defined in the patent claims and differ from the details disclosed above for the sake of example only.

Patent claims

1. A method for manufacturing optical elements, **characterised** in that the method comprises the steps of supplying a printing cylinder (20) with printing elements (50) for forming optical structures, applying optical material on the printing cylinder and creating the optical structures on the substrate material web (W) or substrate material sheets.

2. A method according to claim 1, **characterised** in that the printing process is a gravure printing process or a gravure offset process or a flexographic printing process or an offset lithography or electrophotographic printing process or a combination of these.

3. A method according to claim 1 or 2, **characterised** in that the method comprises a step of printing with hot stamping printing method or digital printing method or with silk screen printing method or with photolithographic printing method or a combination of these.

4. A method according to any of claims 1 to 3, **characterised** in that the method comprises a step of laminating the printed substrate material.

5. A method according to any of claims 1 to 4, **characterised** in that the method comprises a step of embossing the printed optical material layer.

6. A method according to any of claims 1 to 5, **characterised** in that the substrate material is paper and/or plastic and/or passive and/or active optical/electrical material, such as a semiconductor material.

7. A method according to any of claims 1 to 6, **characterised** in that the substrate material comprises hybrid material consisting of metal, glass, laminate and/or composite.

8. A method according to any of claims 1 to 7, **characterised** in that the method comprises a step of treating the optical material after the printing step with the use of light and/or laser activation and/or thermal activation or other post-treatment method.

9. A method for manufacturing a printing cylinder for the use in the printing unit for manufacturing optical elements, which printing cylinder comprises a printing surface, **characterised** in that the method comprises the steps of:
   - applying a gray-scale mask on the fabrication of the printing surface,
   - exposing photosensitive materials through the gray-scale mask with electromagnetic radiation,
   - removing the gray-scale mask, and
   - etching the printing surface to a printing plate or to the cylinder.

10. A method according to claim 9, **characterised** by exposing a photosensitive material on the printing plate through the gray-scale mask with electromagnetic radiation, preferably UV light.

11. A method according to claim 9 or 10, **characterised** by etching the printing plate using the CAIBE method, the RIE method, or other etching method.

12. A printing system for carrying out the method according to claims 1 to 8, **characterised** in that the printing system comprises a printing cylinder provided with printing elements (50) for printing optical elements.

13. A printing system according to claim 12, **characterised** in that the printing system is a gravure printing system comprising a gravure printing cylinder provided with printing elements (50) for printing optical elements.

14. A printing system according to claim 12, **characterised** in that the printing system is a gravure offset system comprising a printing cylinder provided with printing elements (50) for printing optical structures and an offset cylinder for creating the optical structure on the substrate material.

15. A printing system according to claim 12, **characterised** in that the printing system is a flexographic printing system.

16. A printing system according to claim 12, **characterised** in that the printing system is an offset lithographic printing system.

17. A printing system according to claim 12, **characterised** in that the printing system is an electrophotographic printing system.

18. A printing system according to any of claims 12 to 17, **characterised** in that the printing system is a combined printing system comprising a combination of gravure and/or flexographic and/or offset lithographic and/or electrographic and/or digital printing and/or embossing techniques and/or silk screen printing and/or hot stamping techniques and/or photolithographic printing.

19. A printing system according to any of claims 12 to 18, **characterised** in that the printing system comprises a laminating unit.

20. An optical element comprising a substrate layer and a layer of optical structures, **characterised** in that the substrate layer (31) of the optical element (30) is paper.

21. A printed optical element, **characterised** in that the optical structures are printed on substrate material with a printing system comprising a printing cylinder.

22. A printed optical element according to claim 21, **characterised** in that the substrate material is paper and/or plastic and/or passive and/or active optical/electrical material, such as a semiconductor material.

23. A printed optical element according to claim 21 or 22, **characterised** in that the substrate material comprises hybrid material consisting of metal, glass, laminate and/or composite.

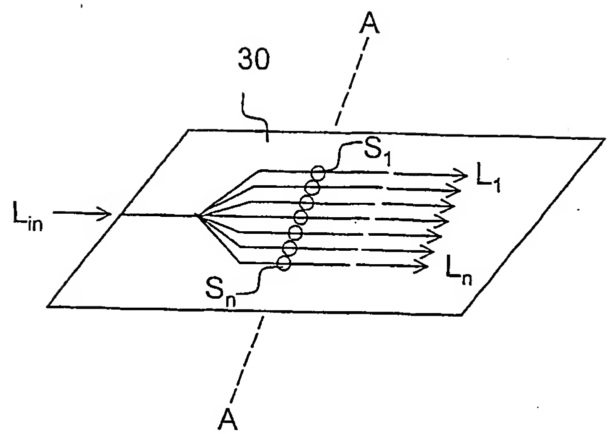

FIG. 1A

CUT A-A

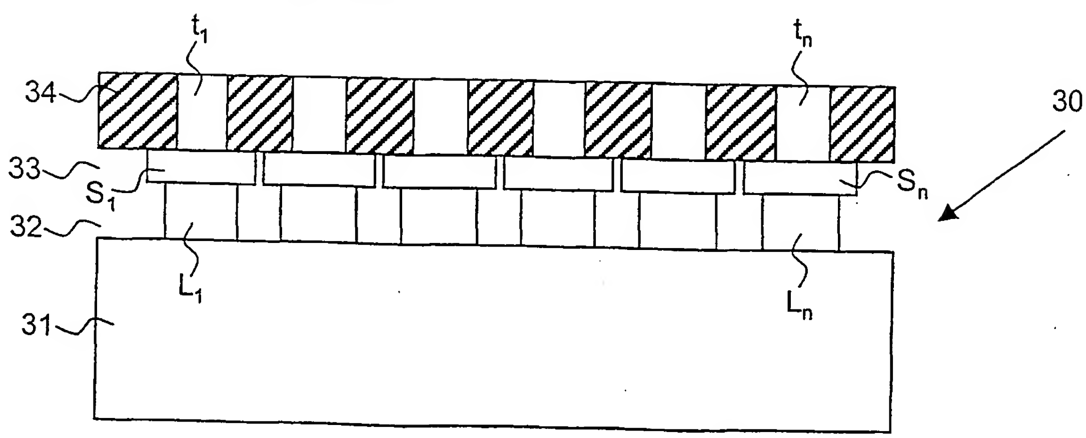

FIG. 1B

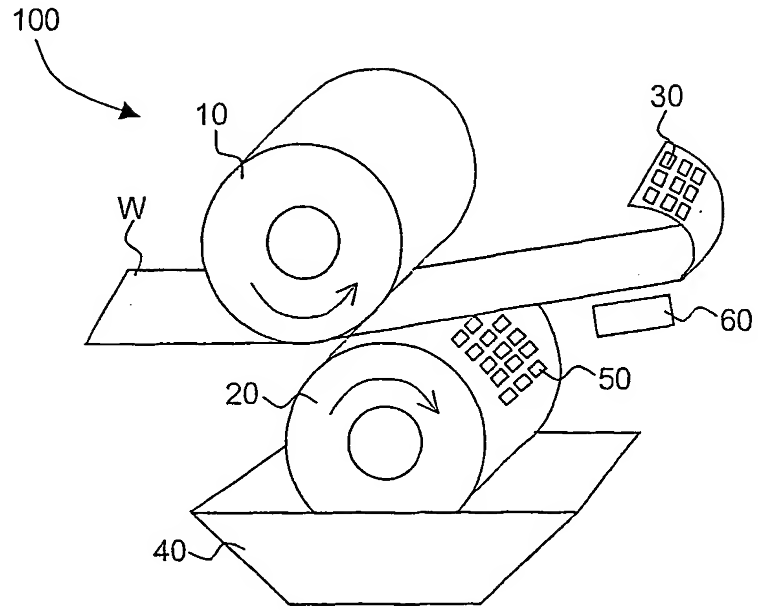

FIG. 2

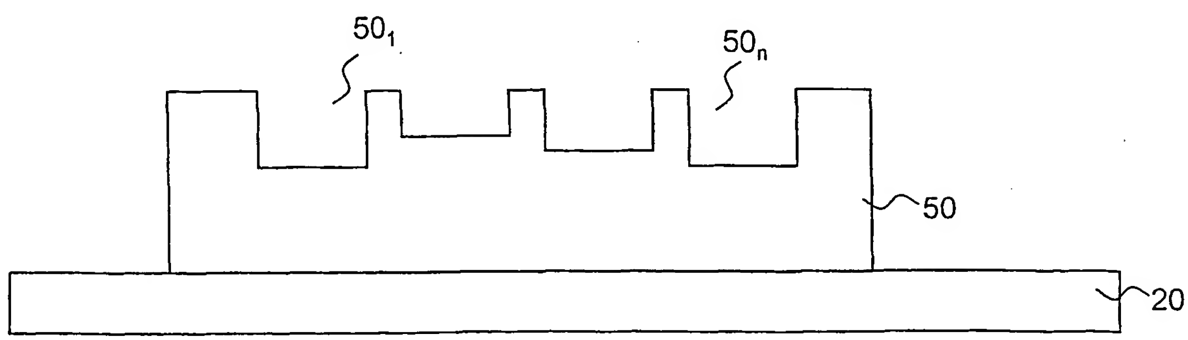

FIG. 3

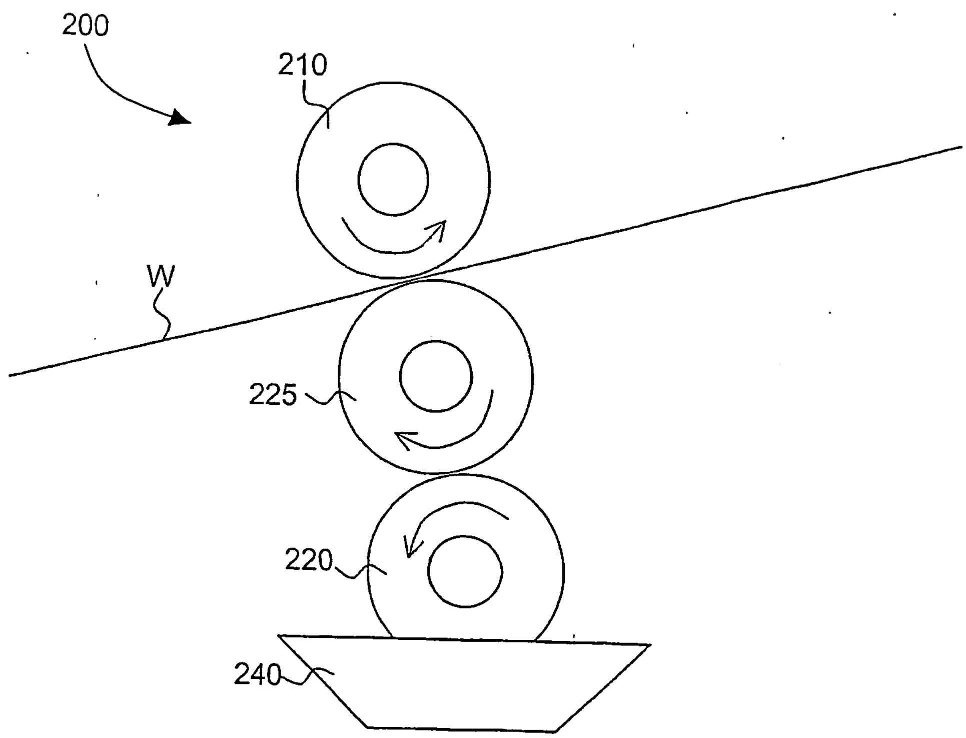

FIG. 4

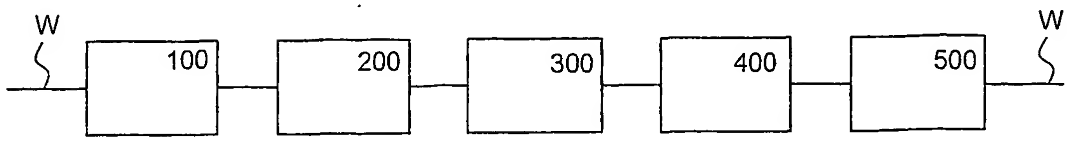
W
100
200
300
400
500
W

FIG. 5A

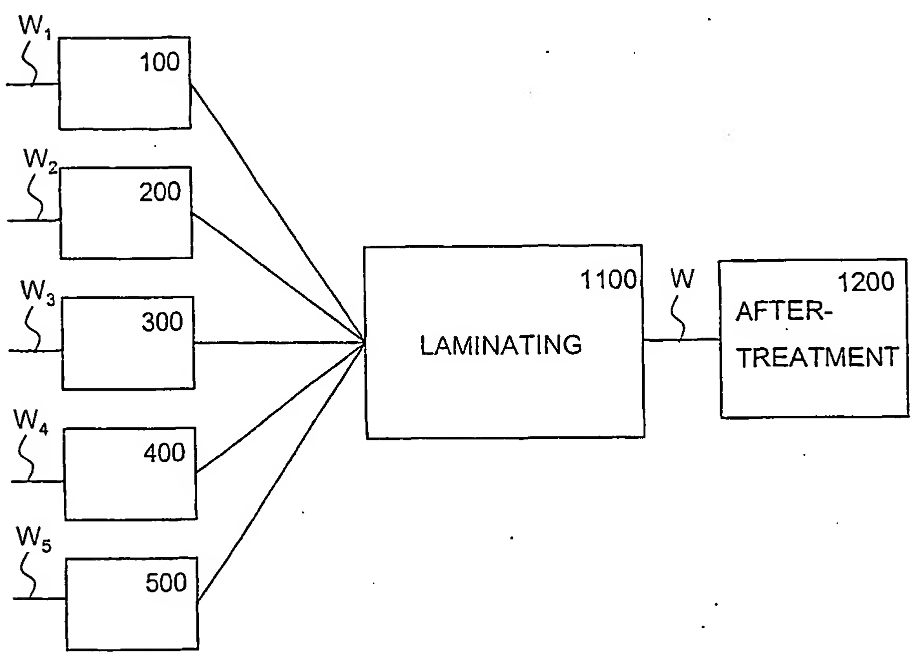
W1
100
W2
200
W3
300
W4
400
W5
500
1100
LAMINATING
W
1200
AFTER-
TREATMENT

FIG. 5B

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

There are two inventions, namely

1. An invention relating to the manufacturing of optical elements, defined in claims 1-8 and 12-23.

2. An invention relating to the manufacturing of a printing cylinder, defined in claims 9-11.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☒ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 02/00020

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: G02B 6/10, G03F 7/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: G02B, B41M, G03F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO INTERNAL, WPI DATA, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 0053423 A1 (AMERICAN BANK NOTE HOLOGRAPHICS, INC.), 14 Sept 2000 (14.09.00), page 1, line 12 - line 15; page 3, line 7 - line 9; page 7, line 3 - line 20, page 8, lines 7-9; page 9, line 30 - page 10, line 4; page 11, lines 1-4; page 13, lines 1-3; page 17, lines 22-24; page 18, lines 21-23; figures 1A,8 --	1-8,12-23
X	US 6120636 A (ROBERT B. NILSEN ET AL), 19 Sept 2000 (19.09.00), column 2, line 8 - line 31; column 5, line 22 - line 27; column 9, line 1 - line 28 --	1-8,12-23

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
6 May 2000	14 -05- 2002

Name and mailing address of the ISA/	Authorized officer
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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 0030854 A1 (NILPETER A/S), 2 June 2000 (02.06.00), page 3, line 16 - line 29; page 12, line 14 - line 15; page 15, line 14 - line 17, figure 1, claim 7 --	1-8,12-23
X	US 5116548 A (DONALD W. MALLIK ET AL), 26 May 1992 (26.05.92), column 1, line 10 - line 16; column 4, line 53 - line 60; column 5, line 12 - line 61, column 8, lines 42 - 45; claims 17-19 --	1-8,12-23
X	US 3740222 A (A.D. MCGLASHAN, SR), 19 June 1973 (19.06.73), claim 1 -- --------	9-11

INTERNATIONAL SEARCH REPORT
Information on patent family members

01/05/02

International application No.
PCT/FI 02/00020

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 0053423 A1	14/09/00	AU 3879500 A	28/09/00
US 6120636 A	19/09/00	CA 2318039 A	29/07/99
		EP 1051291 A	15/11/00
		JP 2002500969 T	15/01/02
		WO 9937470 A	29/07/99
		US 6119751 A	19/09/00
WO 0030854 A1	02/06/00	AU 1374700 A	13/06/00
		EP 1150843 A	07/11/01
US 5116548 A	26/05/92	US 5083850 A	28/01/92
		US 5085514 A	04/02/92
US 3740222 A	19/06/73	NONE	

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